QCD fits in diffraction

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Work done in collaboration with :
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1. QCD (DGLAP) analysis of HERA data ($F_2^{D(3)}$) implications for Tevatron…

2. Good and Walker (dipole) approaches :
    a. 2 gluons exchange model
    b. BFKL parameterisation of $F_2^{D(3)}$

In progress : « saturation » based models

QCD (DGLAP) fits

QCD fits on HERA data

$$F_2^{D(3)} = \Phi_{IP}(x_{IP})\, F^{QCD}(\beta, Q^2) + N_{IR}\, \Phi_{IR}(x_{IP})\, F^{IR}(\beta, Q^2)$$

With input (Q_0^2) distributions :

$$zS(z, Q^2 = Q_0^2) = \left[A_S z^{B_S}(1-z)^{C_S}(1 + D_S z + E_S\sqrt{z}\right] \cdot e^{\frac{0.01}{z-1}}$$

$$zG(z, Q^2 = Q_0^2) = \left[A_G(1-z)^{C_G}\right] \cdot e^{\frac{0.01}{z-1}}$$

Reproduction of **fit A** from H1 publication
$E_S = D_S = 0$
and Q_0^2 scanned to find the best χ^2

parameters	Our fit on H1 data	Table 3 of Ref. [2] (fit A)
Q_0^2	1.75 GeV^2	1.75 GeV^2
Q_{min}^2	8.5 GeV^2	8.5 GeV^2
$\alpha_{\mathbf{P}}$	1.118 ± 0.008	1.118 ± 0.008
A_S	1.10 ± 0.32	1.06 ± 0.32
B_S	2.33 ± 0.35	2.30 ± 0.36
C_S	0.61 ± 0.15	0.57 ± 0.15
A_G	0.13 ± 0.03	0.15 ± 0.03
C_G	-0.92 ± 0.16	-0.95 ± 0.20
N_{IR}	$2.8 \ 10^{-3} \pm 0.4 \ 10^{-3}$	$1.7 \ 10^{-3} \pm 0.4 \ 10^{-3}$

Data sets for the analysis : all existing measurements

$$e+p \rightarrow e + X \text{ (GAP) } Y$$

Data Samples published:
1. H1 LRG ($M_Y < 1.6$ GeV)
2. H1 FPS ($M_Y = Mp$: proton tagged but limited kinematic acceptance)
3. ZEUS FPC ($M_Y < 2.3$ GeV)
**4.** ZEUS LPS ($M_Y = Mp$)

All samples converted to $M_Y < 1.6$
$\Rightarrow$ H1 FPS *1.23 (conversion factor from elastic to $M_Y < 1.6$ GeV)
$\Rightarrow$ ZEUS LPS *1.23
$\Rightarrow$ ZEUS FPC *0.85(=0.70*1.23)

Strategy : we add parameters (E_S, D_S) to get a result stable w.r.t.
initial parameterisation

$\Rightarrow$ We do the fits independently on H1 LRG and ZEUS FPC
$\Rightarrow$ Then, on the 4 combined data sets
$\Rightarrow$ **kinematic space ($Q^2 > 4.5$ GeV², $M_X > 2$ GeV, $\beta < 0.8$)**

Result for the S,G distributions (central values)
δ(S)~5% and δ(G)~15% (low z ; >25% at large z)
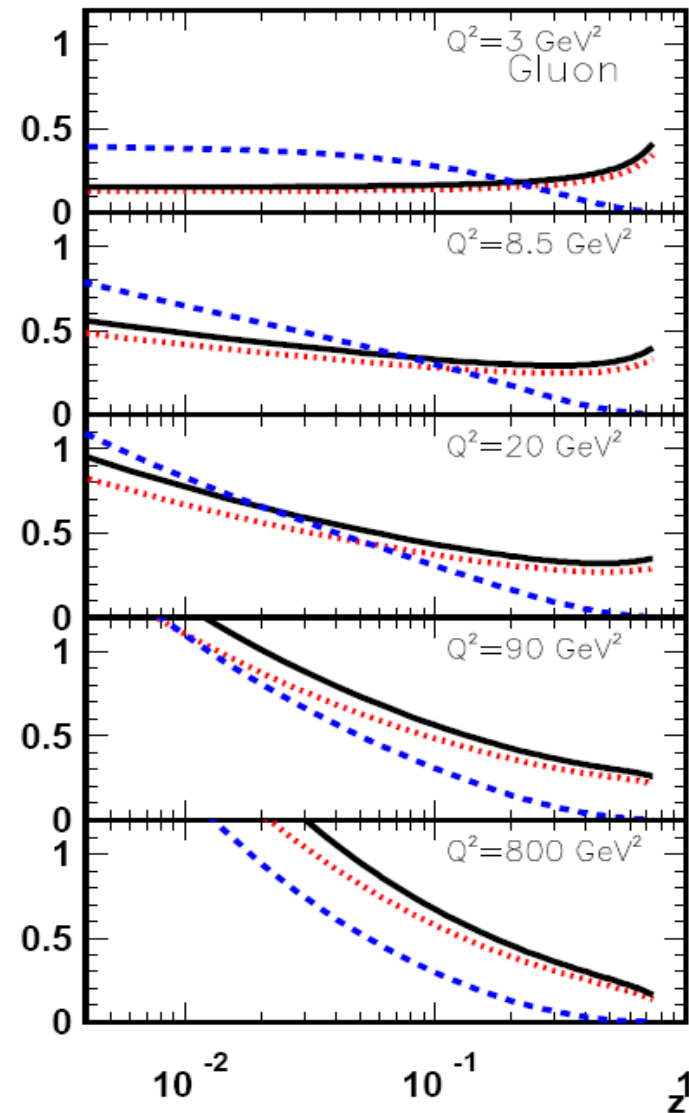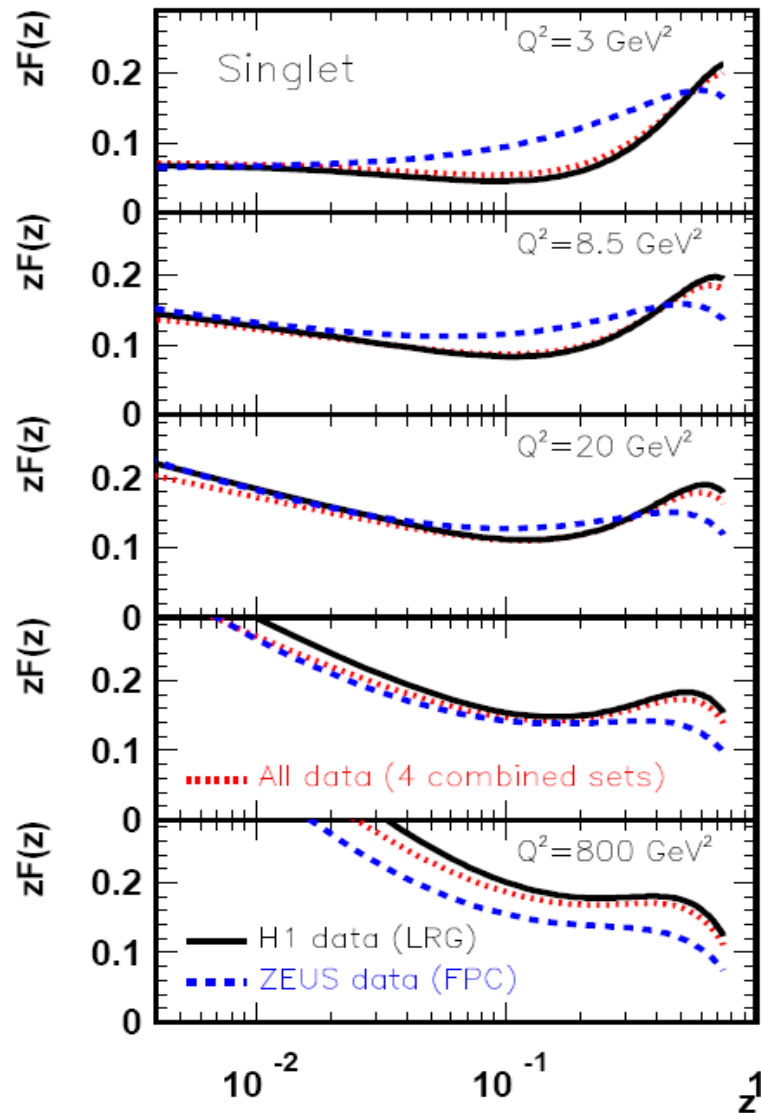
Result for the S,G distributions parameter values

parameters	H1RAP	ZEUSMX	All data seta
Q_0^2	3 GeV^2	3 GeV^2	3 GeV^2
Q_{min}^2	4.5 GeV^2	4.5 GeV^2	4.5 GeV^2
$\alpha_{\mathbb{P}}$	1.120 ± 0.007	1.104 ± 0.005	1.118 ± 0.005
A_S	0.28 ± 0.09	0.12 ± 0.02	0.30 ± 0.15
B_S	0.13 ± 0.08	-	0.14 ± 0.11
C_S	0.38 ± 0.08	0.50 ± 0.06	0.45 ± 0.13
D_S	6.14 ± 0.82	5.65 ± 1.24	5.72 ± 0.92
E_S	-3.98 ± 0.22	-	-3.66 ± 0.19
A_G	0.24 ± 0.06	0.74 ± 0.15	0.20 ± 0.06
C_G	-0.76 ± 0.19	3.36 ± 1.16	-0.76 ± 0.21
$N_{IR}(H1RAP)$	5.77 ± 0.55	-	6.65 ± 0.47
$N_{IR}(ZEUSMX)$	-	-	-
$N_{IR}(H1TAG)$	-	-	5.06 ± 0.52
$N_{IR}(ZEUSTAG)$	-	-	4.64 ± 0.48

| Data set	χ^2 (stat. error)	χ^2 (stat. and syst. error)	nb of data points
H1 [2]	302.0	217.9	240
H1 [3]	50.1	27.5	57
ZEUS [4]	192.8	109.5	102
ZEUS [5]	52.1	22.7	45

Good description!

no dependence in Q_0^2
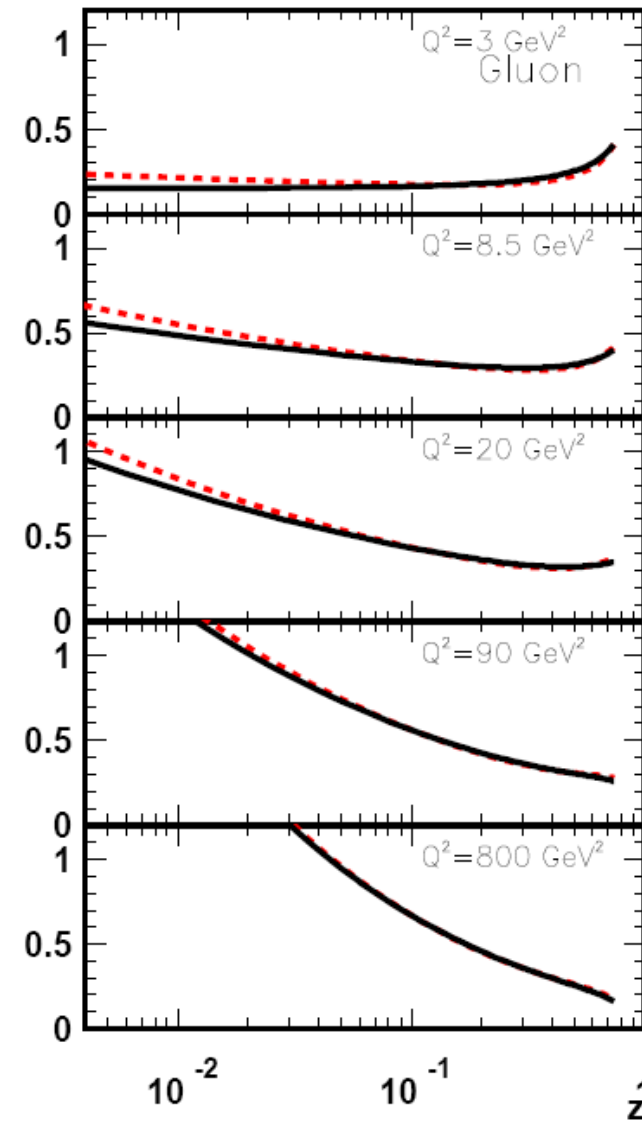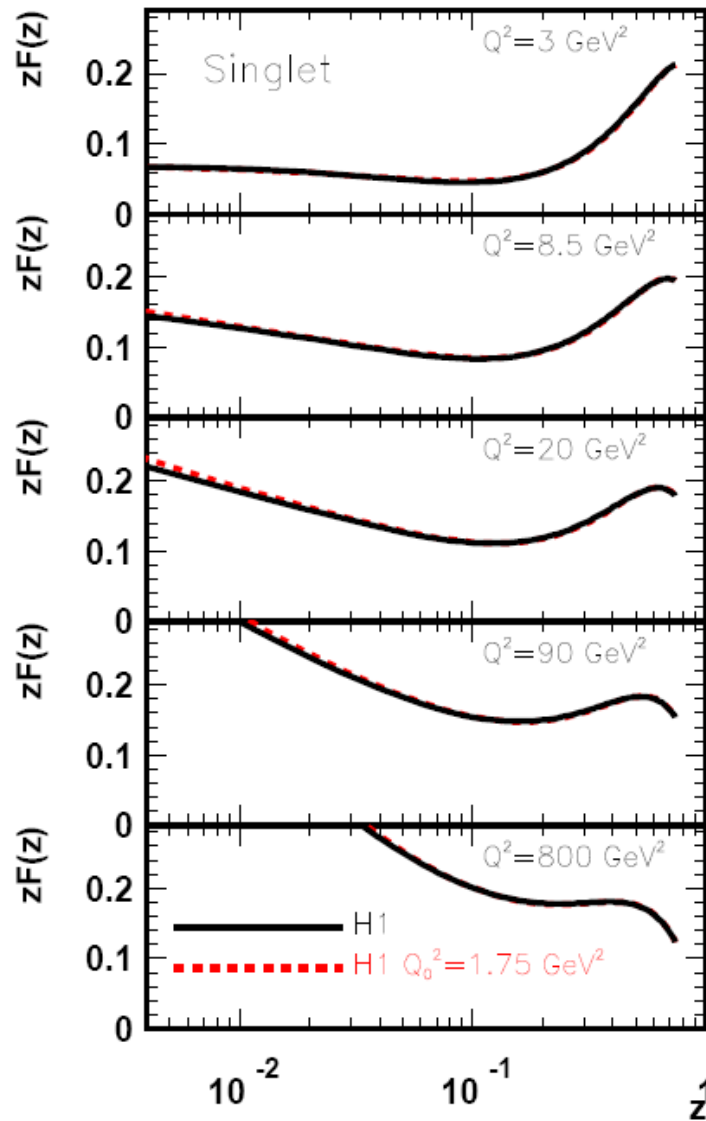
no dependence in Q_{min}^2 => 4.5 GeV² is used (≠H1 publi)
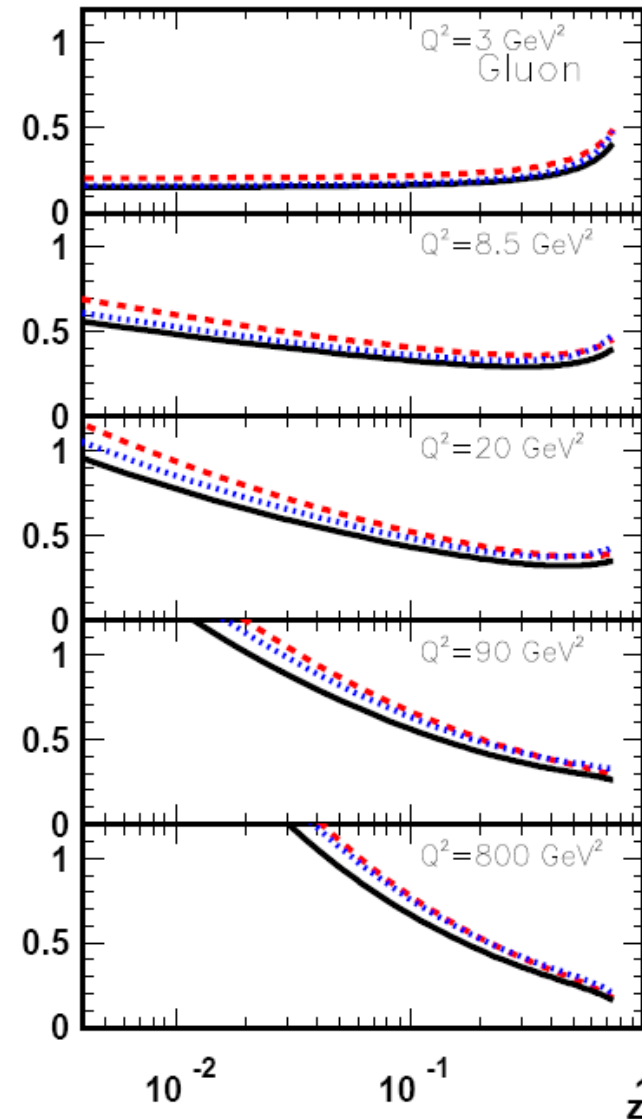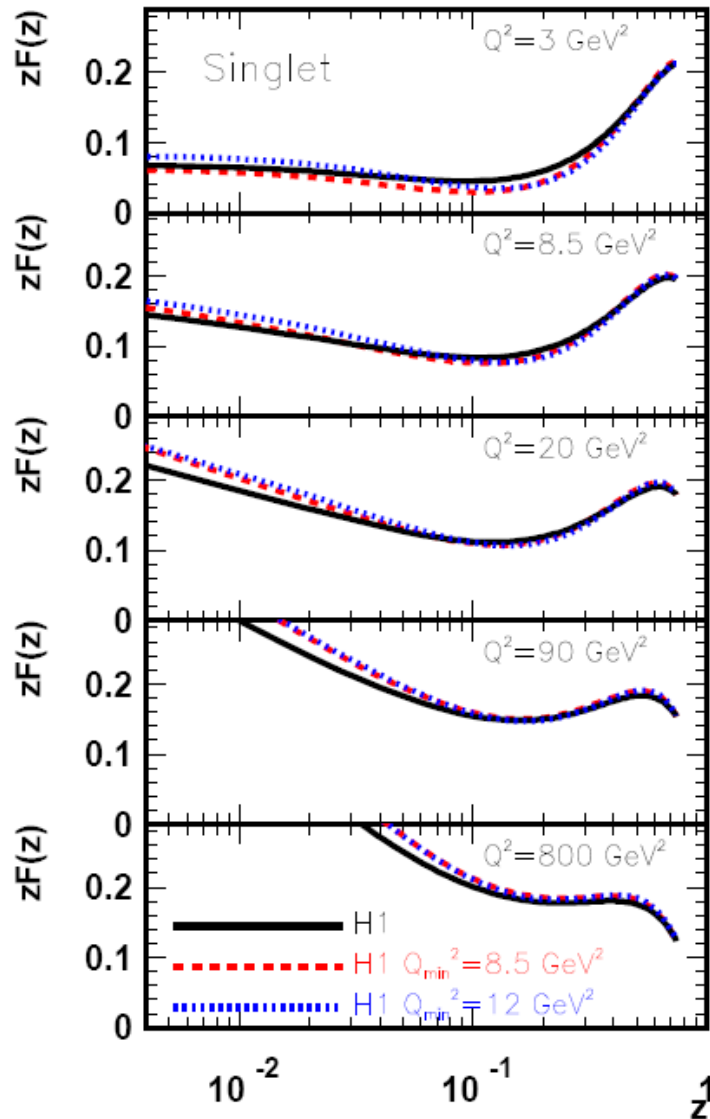
Impact for Tevatron

- Possible measurement of the dijet mass fraction at the Tevatron sensitive to gluon density

- Request two jets of 25 GeV and a $\bar{p}$ tagged in the DØ dipole roman pot detector as an example
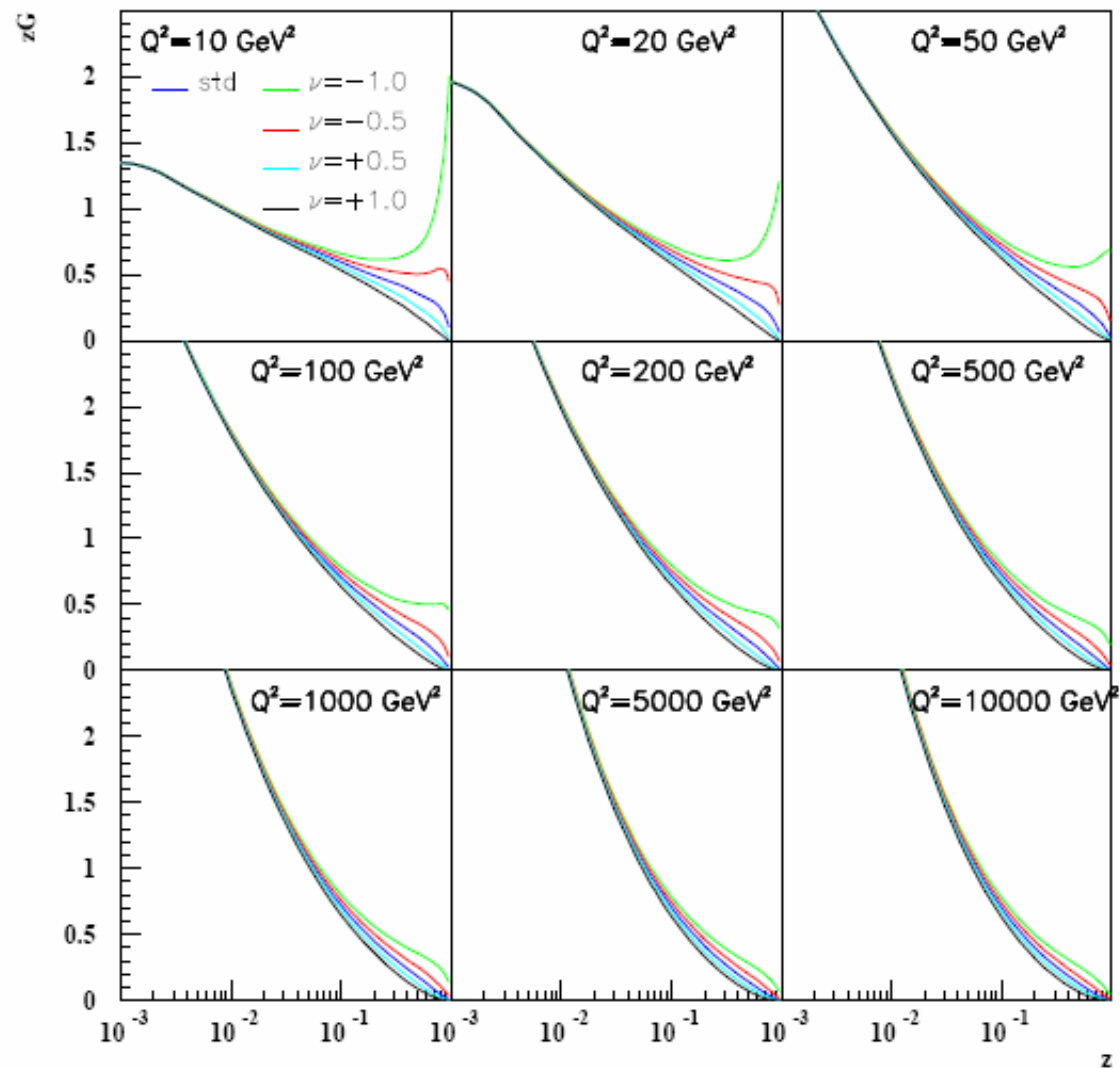
Nucl.Phys.B746:15-28,2006
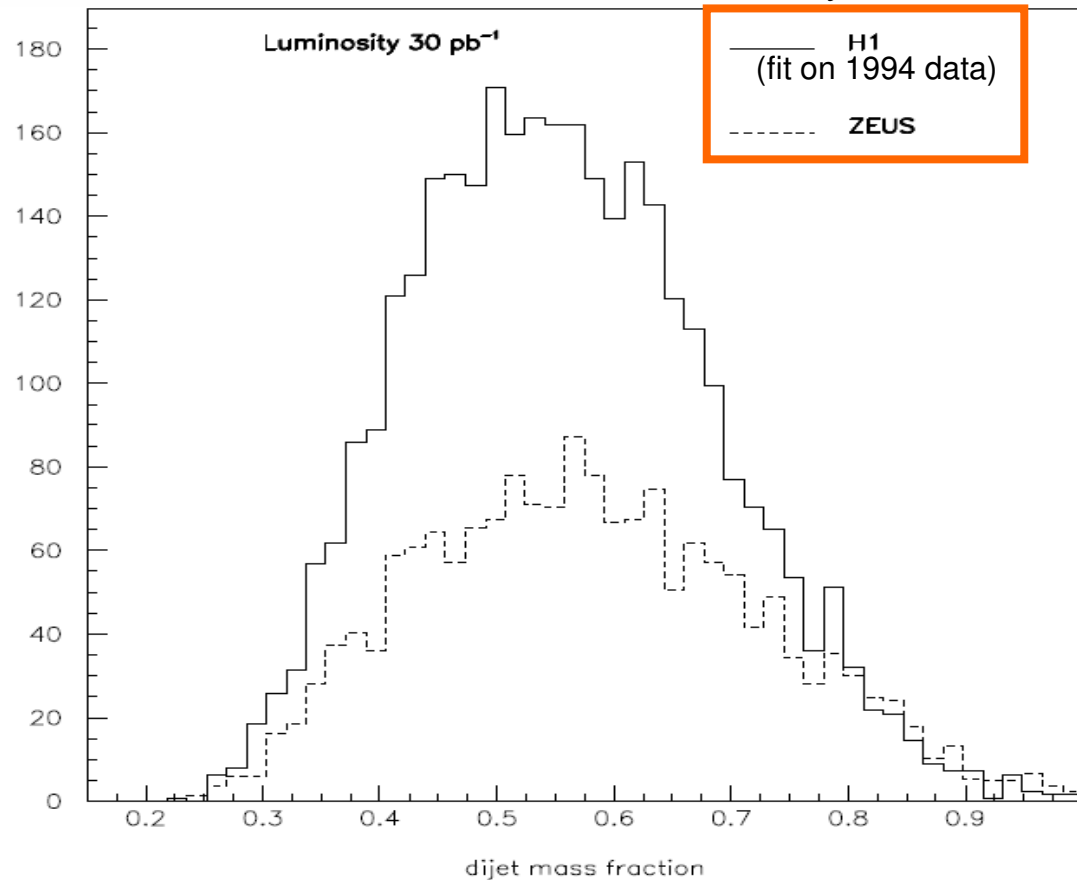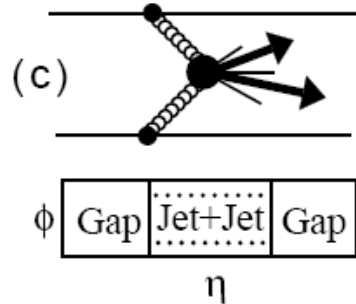
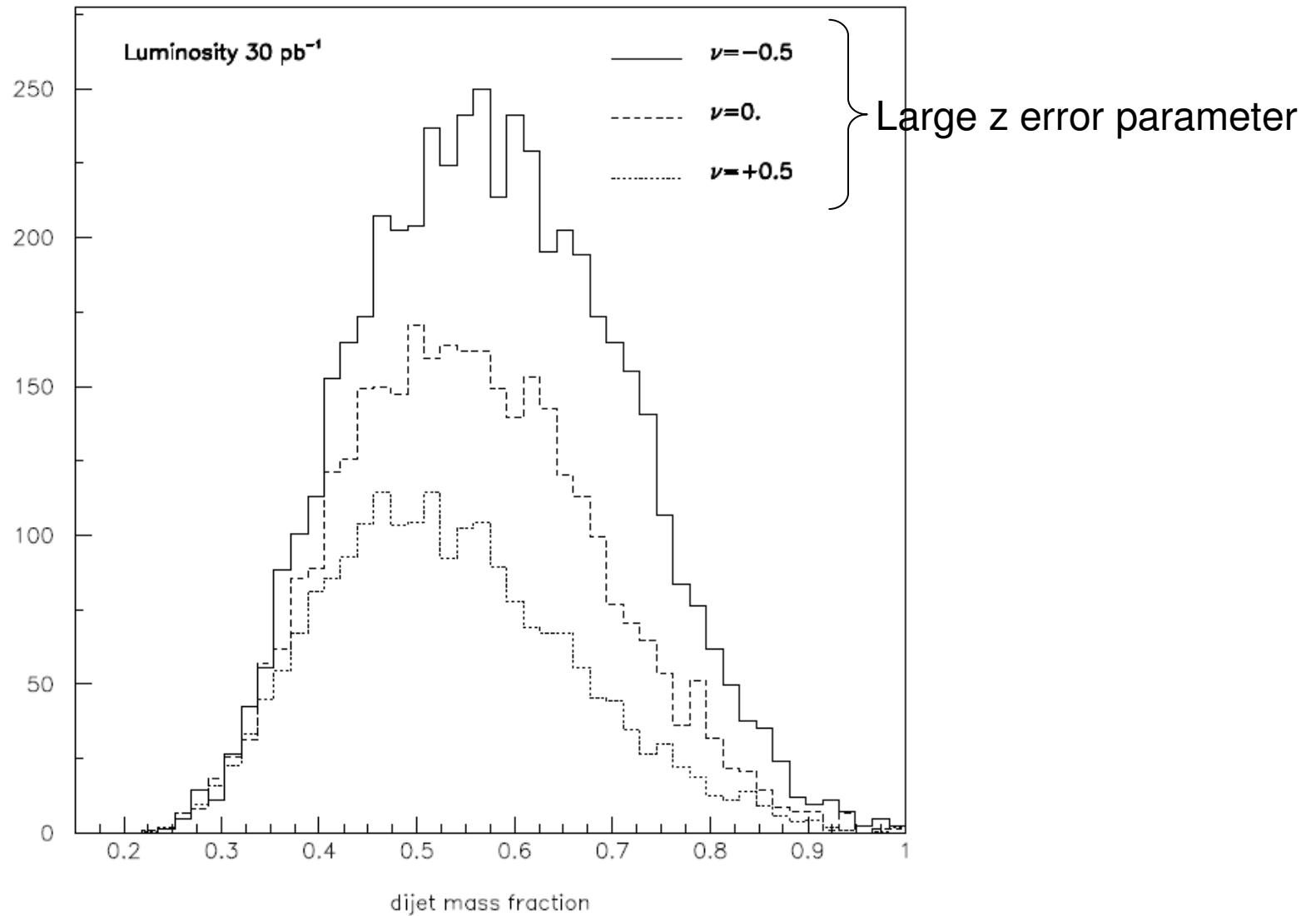# Uncertainty of the Gluon density at large z : multiply zG by $(1-z)^\nu$

Result with the
1994 H1 data
=>
ν = 0.0 +/- 0.6

Impact for Tevatron
Taking into account the poor determination of xG at large z

Status for QCD fits

- PDFs from all data sets compatible (within total error)
- zG => essential piece of information for Tevatron/LHC…
    => direct background to inclusive/exclusive Higgs prod.
      at LHC!
    => better understanding of the large z Gluon density

- Pb : the whole procedure needs α_{DIFF} to be constant(Q^2) ?
  compatible with ZEUS published result ?
   (*under investigation in H1 : HERAII data aviable*)

« Dipole » model fits

Two-gluon exchange Model

- LO realisation of the Singlet Exchange **+ γ* wave function**

- BEKW parametrisation: **[J. Bartels at al., Eur.Phys.J. C7, 443 (1999)]**
  - → Modified form used **[ZEUS coll., Nucl. Phys. B713 (2005)]**

$$x_{\mathbb{P}} F_2^{D(3)} = c_T \cdot F_{q\bar{q}}^T + c_L \cdot F_{q\bar{q}}^L + c_g \cdot F_{q\bar{q}g}^T \qquad \textbf{+IR}$$
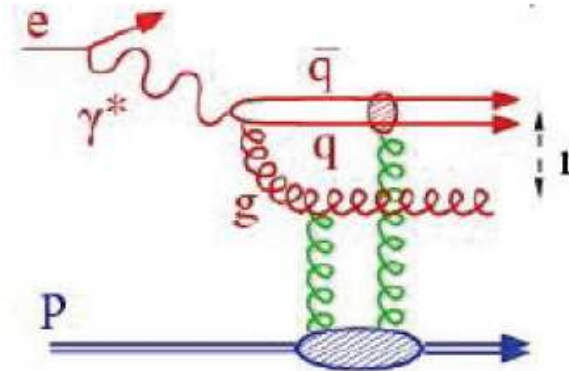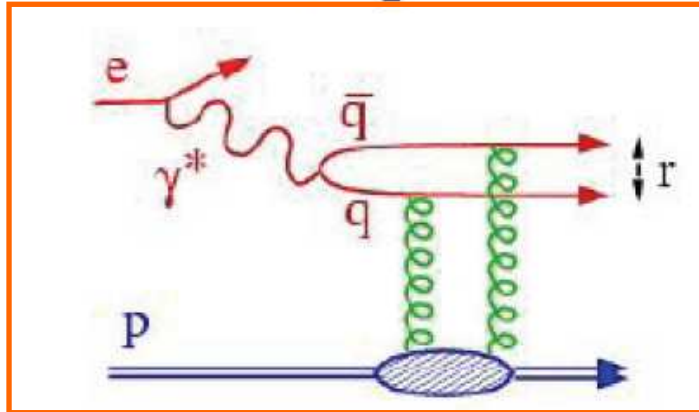
- Dominant terms:

$$F_{q\bar{q}}^T \;\; \alpha \;\; \beta(1-\beta)$$

↘ At medium β

$$F_{q\bar{q}g}^T \;\; \alpha \;\; \log\left(1+\frac{Q^2}{Q_0^2}\right)(1-\beta)^\gamma$$

↘ At low β

$$F_{q\bar{q}}^L \;\; \alpha \;\; \frac{Q_0^2}{(Q^2+Q_0^2)} \; \log^2\left(\frac{7}{4}+\frac{Q^2}{4\beta Q_0^2}\right)\beta^3(1-2\beta)^2$$

↘ At large β

↘ Compare to data

Combined fit on the 4 data sets

| Data set	χ^2 (total error)	nb of data points
H1 [2]	374.0	247
H1 [3]	47.3	59
ZEUS [4]	104.6	142
ZEUS [5]	27.0	45

Kinematic space
$Q^2 > 4.5$ GeV²
(no need for any cut in M_X, β)

Fit result plotted with H1 LRG and ZEUS FPC data sets

Good description

ZEUS data (Mx)
H1 data (LRG)

$x_{IP} F_2^{D(3)}$

$\beta=0.01$ $\beta=0.04$ $\beta=0.1$ $\beta=0.2$ $\beta=0.4$ $\beta=0.65$ $\beta=0.9$ Q^2 [GeV²]

3.5, 5, 6.5, 8.5, 12, 15, 20, 25, 35, 45, 60, 90, 200, 400, 800, 1600

x_{IP}
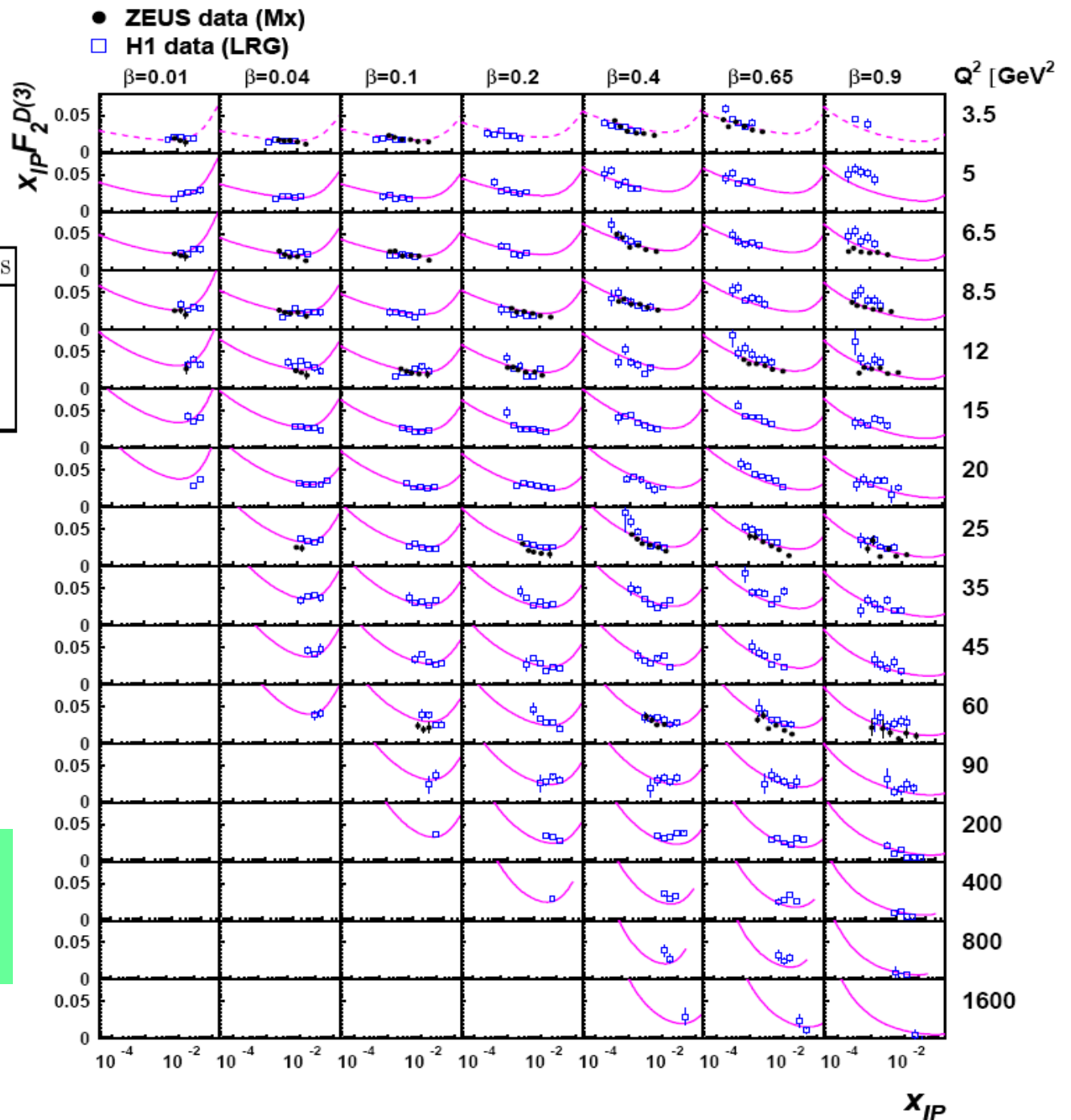
For illustration we show the same fit with preliminary H1 measurements
(not included in the fit : **99-00** and **04**)
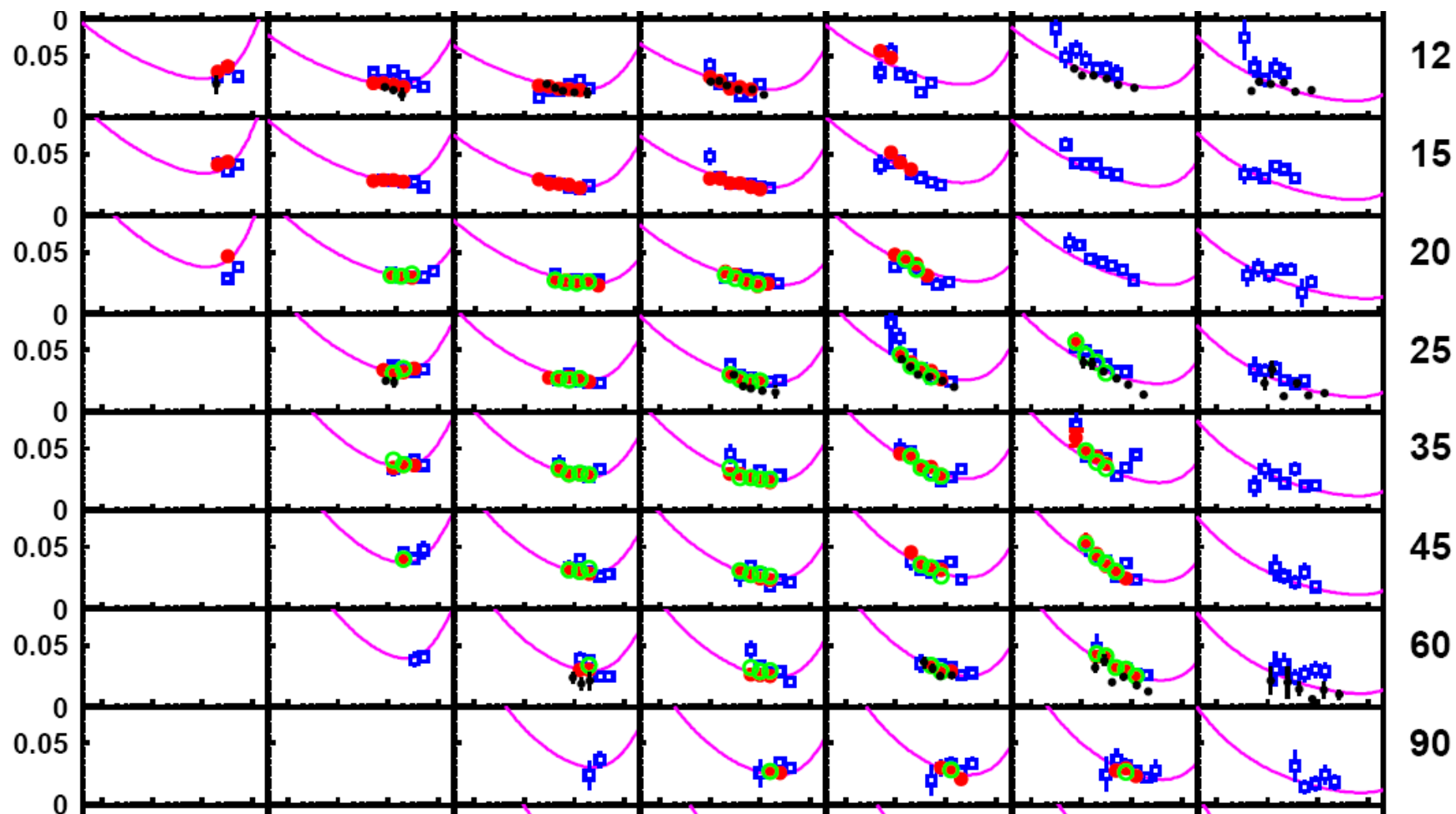
The different components from the BEKW fit

(L) component

parameters	value
$A(q\bar{q}_T)$	10.55 ± 0.18
$B(q\bar{q}g_T)$	1.67 ± 0.20
$C(q\bar{q}_L)$	7.95 ± 1.00
n_2^0	0.08 ± 0.02
n_2^1	0.07 ± 0.01
n_4^0	0.18 ± 0.06
n_4^1	$0.$
γ	9.79 ± 0.41
Q_0^2	2.53 ± 0.54
$N_{IR}(H1 \; [2])$	6.18 ± 0.48
$N_{IR}(H1 \; [3])$	4.03 ± 0.53
$N_{IR}(ZEUS \; [5])$	3.46 ± 0.48

$n(Q^2)=n_2^0+n_2^1 \ln(1+Q^2/Q_0^2)$

x_{IP} dependence in

$(1/x_{IP})^{n(Q^2)}$

=> Q² dependence of α_{IP}

$x_{IP}=0.002$

BEKW(mod):

Total
$(q\bar{q}g)_T$
$(q\bar{q})_T$
$(q\bar{q})_L$
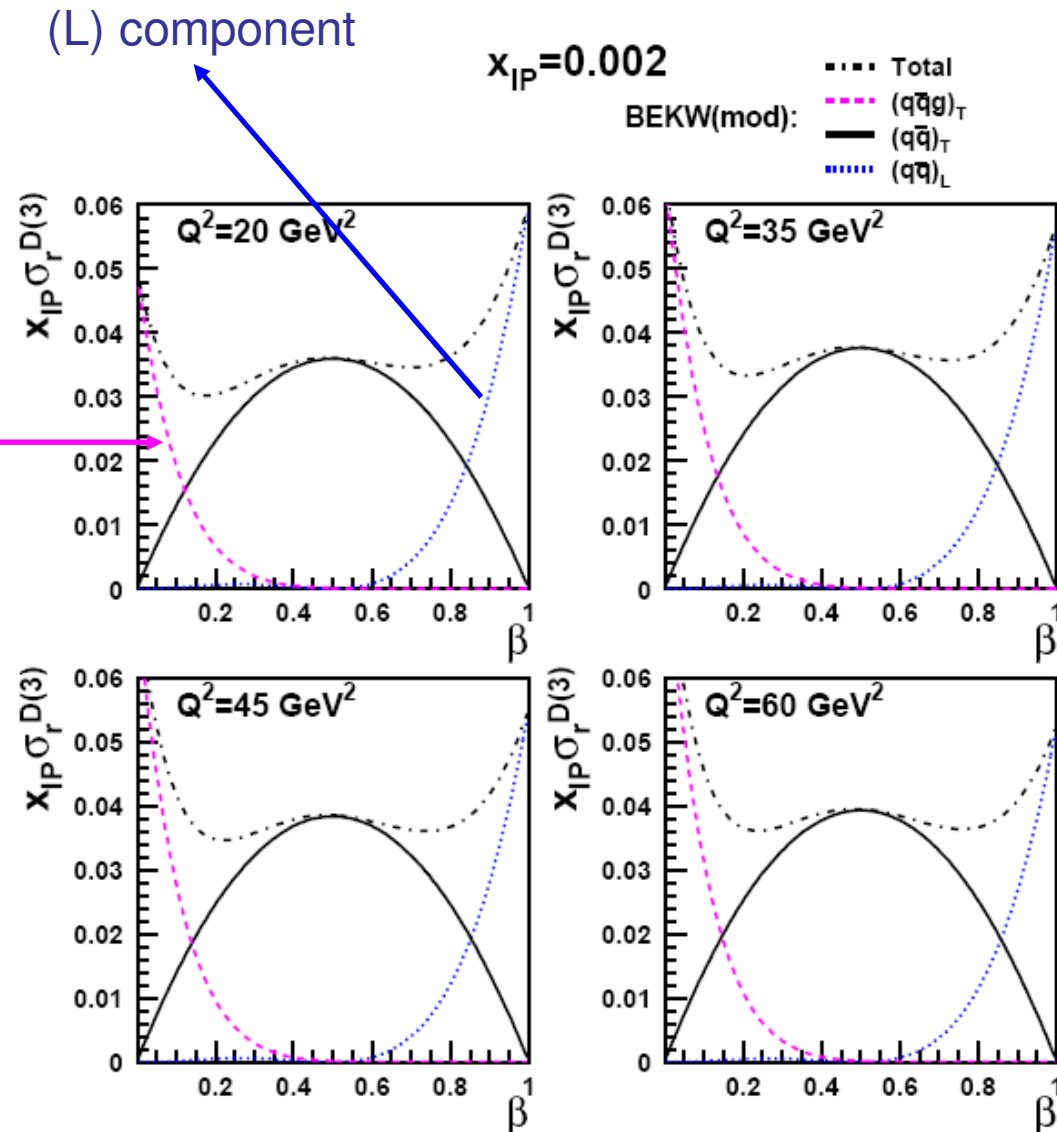
Status of BEKW fits

- Economic and efficient parameterisation of all data!
  over the whole kinematic range (better than QCD-DGLAP fits)
  dependences on all variables in good agreement with data

- In this model : α_{DIFF} depends of Q^2
  => precise experimental data are essential here...

BFKL dipole approach :
Bialas, Peschanski '97 '98 and Munier et al., '98
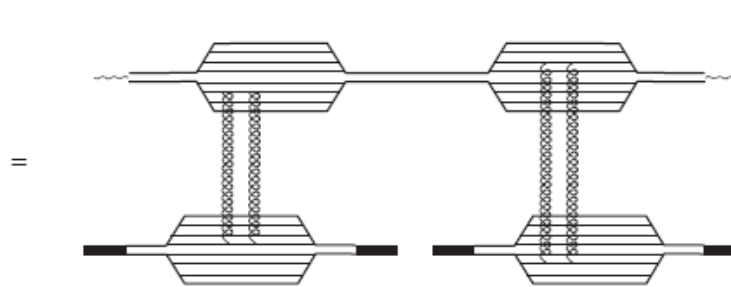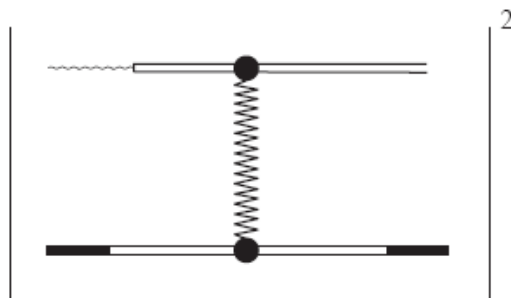
2 components

Elastic
dominant at
intermediate β
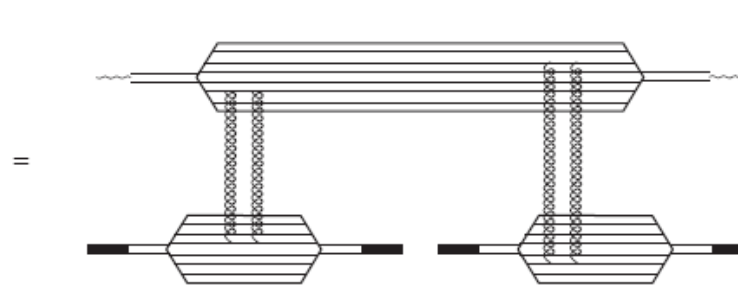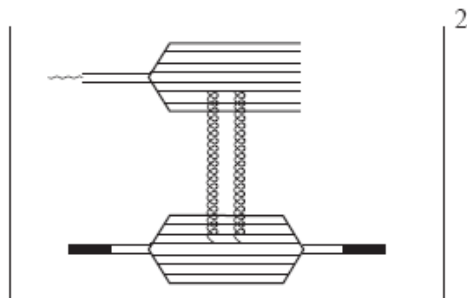
Inelastic
dominant at
small β
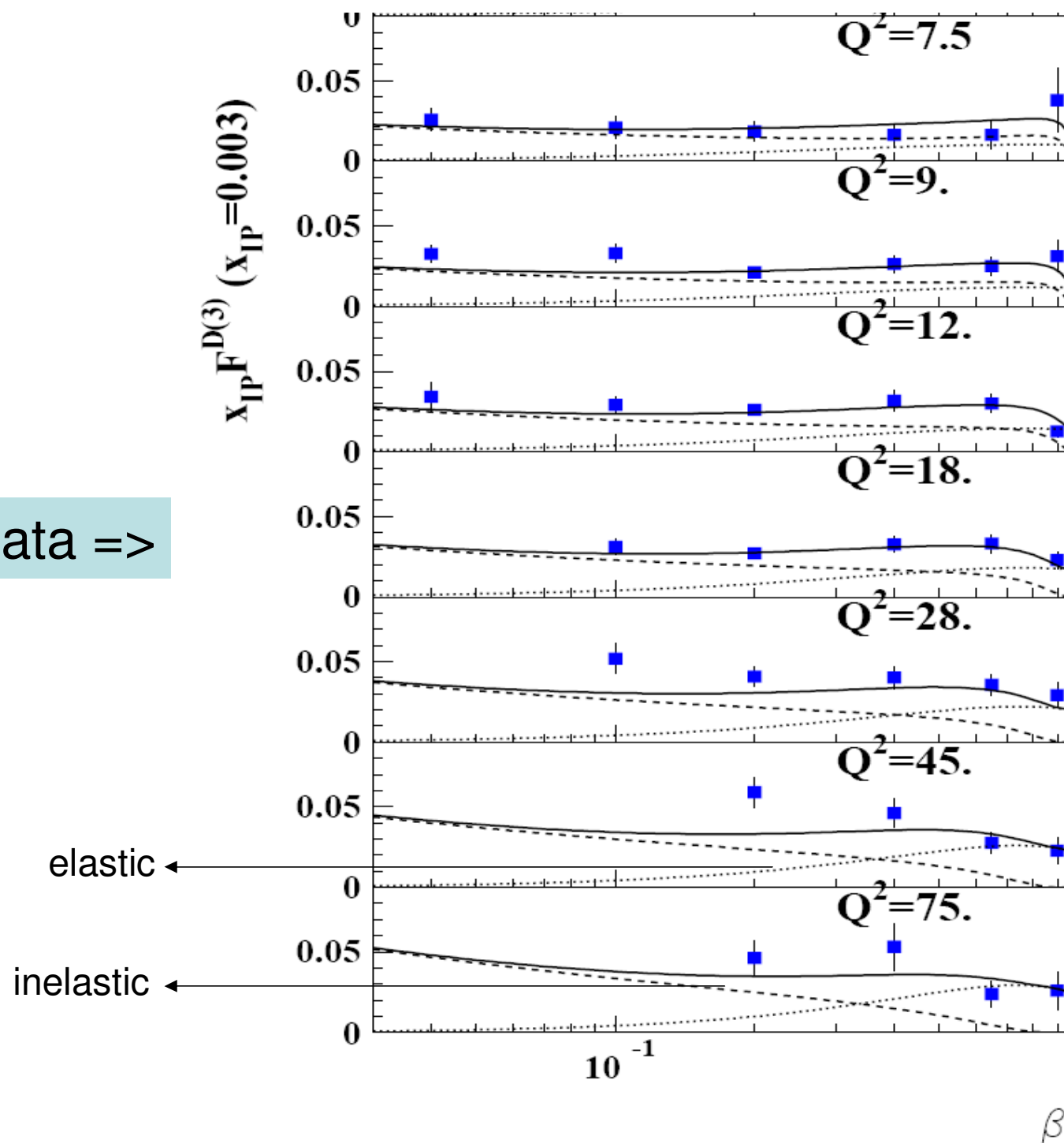(large Mx)

$$F_2^{D(3)} = \frac{1}{N_C e^2} \left(N^{in}(F_T^{D(in)} + F_L^{D(in)}) + N_T^{el} F_T^{D(el)} + N_L^{el} F_L^{D(el)} + N_R F_2^{\mathbb{R}} \right)$$

Reminder from
Nucl.Phys.B534:297-317,1998
the different components

With data =>

elastic

inelastic

$Q^2=7.5$

$Q^2=9.$

$Q^2=12.$

$Q^2=18.$

$Q^2=28.$

$Q^2=45.$

$Q^2=75.$

$x_{IP} F^{D(3)} (x_{IP}=0.003)$

10^{-1}

β
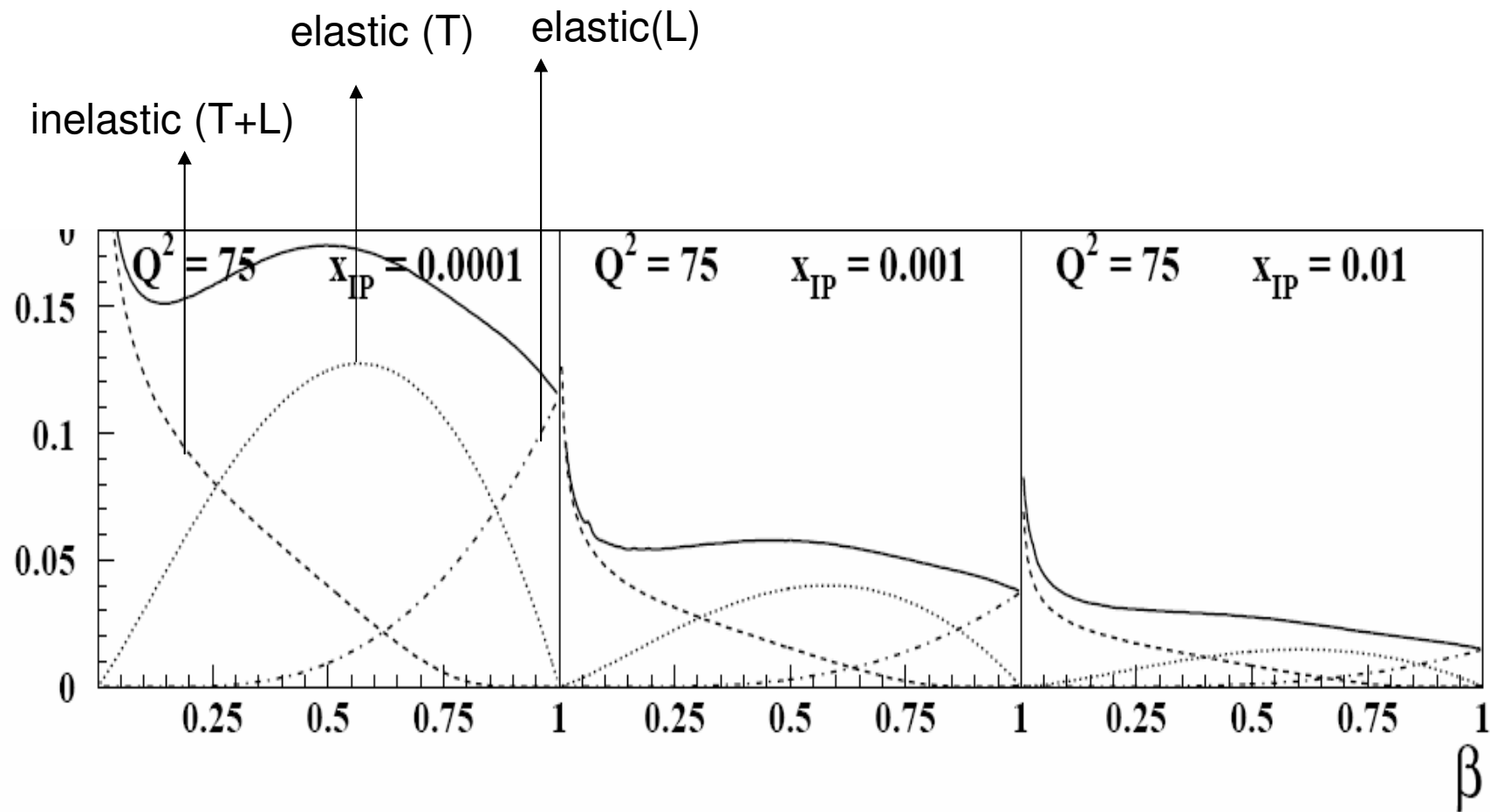
Combined fit
on the 4 data sets

Data set	χ^2 (total error)	nb of data points
H1 [2]	361.6	232
H1 [3]	32.8.7	59
ZEUS [4]	189.5	142
ZEUS [5]	17.4	45

No need for a IR component

F_D^{in} => natural factorisation
breaking (Regge)

parameters	value
$\alpha_{\mathbb{P}}$	1.329 ± 0.006
Q_0	0.364 ± 0.009
N^{in}	0.003 ± 0.001
N_T^{el}	127.730 ± 13.776
N_L^{el}	91.455 ± 9.850

quite large (L)!
*But a fit with elastic (L)/(T)~30%
also fine!*

- ● ZEUS data (Mx)
- □ H1 data (LRG)

$x_{IP} F_2^{D(3)}$

$\beta=0.01$ $\beta=0.04$ $\beta=0.1$ $\beta=0.2$ $\beta=0.4$ $\beta=0.65$ $\beta=0.9$ Q^2 [GeV^2]

3.5, 5, 6.5, 8.5, 12, 15, 20, 25, 35, 45, 60, 90, 200, 400, 800, 1600

Q²<120 GeV² for this model

x_{IP}
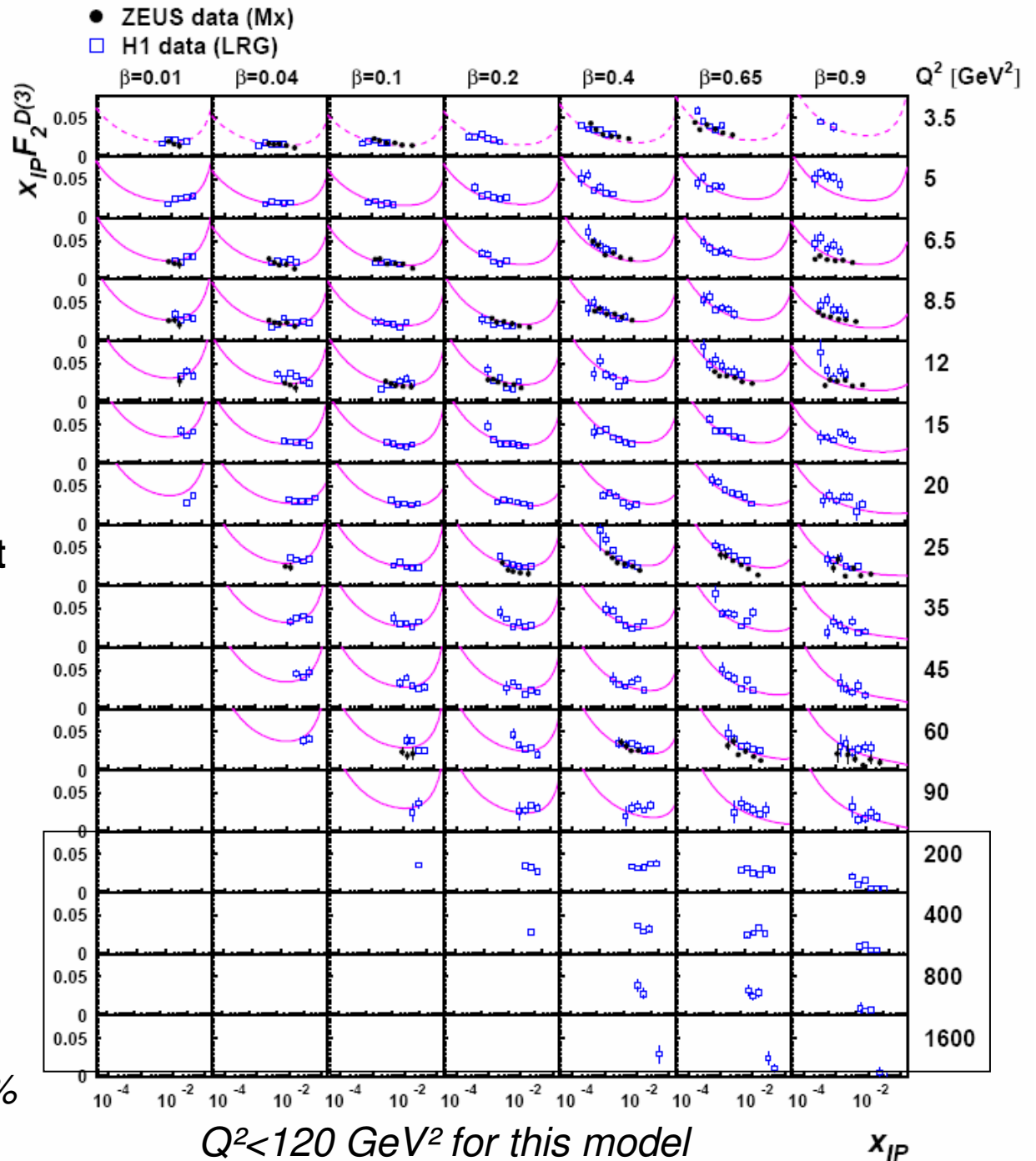
Status of the BFKL dipole fits

- Kinematic range more limited / previous models

- Ratio L/T tends to be large for the favored fit ~60% for the
  elastic component (intermediate β)
  => measurement of FL

- No IR needed! new feature : natural factorisation breaking?

Conclusions

- Different models describe the data with different basis assumptions : $\alpha_{DIFF}(Q^2)$, IR, …

- Today : BEKW approach favored : less parameters/large kinematic range and a good χ^2

  In progress : saturation based models

- *Tevatron/LHC data needed*
- *new prel. H1 analysis with >6 times more Lumi + high Q^2 HERAII data aviable for analysis…*